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NOTES ON GEOGRAPHIC DISTRIBUTION

Amphibia, Anura, Bufonidae, *Rhinella atacamensis*: Altitudinal distribution extension, new records and geographic distribution map

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Amphibian distribution patterns in Chile have been strongly influenced by the formation of physiographic and climatic barriers, mainly the Atacama desert in the north, the Andes mountains in the east, and cold Patagonian steppes in the southeast (Cei 1962; Veloso and Navarro 1988). Other fundamental factor that has influenced the distribution of these organisms in Chile, as well as that of other groups of plants and animals is a climatic gradient characterized by a sustained increment of precipitation level from north to south (Di Castri 1968; Veloso 2006). Along this gradient, the highest degree of species richness among the amphibians is concentrated between 38° and 46° S (Veloso and Navarro 1988; Ortiz and Díaz-Páez 2006), a zone dominated by humid temperate forests (Gajardo 1995). Northward, temperate forests give way to the sclerophyllic forests and shrublands of central Chile, which gradually gives way to the Atacama desert at about 28° S. The vegetational changes mentioned may be directly related to the gradual decrease in the richness of the amphibian fauna progressing northward, both in the coast and in the interior of the country (Cei 1962; Veloso 2006).

The situation is different in the Andes, since northward from 23°47' S, the region corresponding to the Chilean Altiplano, where populations of *Rhinella spinulosa*, *Pleurodema marmorata* and various species of the genus *Telmatobius* may be found (Veloso et al. 1982; Formas et al. 2005). In contrast, there are no records of amphibian populations above 2000 m between 23°47' S (Tilomonte, which is known to be the southern limit of the Altiplano populations of *R. spinulosa* in Chile, Méndez et al., unpublished data) and 31°45' S (Vega Piuquenes, a locality where *P. thaul* was recently recorded, Correa et al. 2007).

Rhinella atacamensis, an endemic Chilean species known until recently as *Bufo atacamensis*, is one of the few amphibians inhabiting the Atacama desert (Figures 1 and 2). Cei (1961, 1962) indicated that the species (referred to as *Bufo spinulosus atacamensis*) consisted only of populations in coastal ravines (Paposo and Aguada de Chorrillos) and the Copiapó and Huasco rivers in the interior desert region (Copiapó and Vallenar) (Figure 1).

Check List **4**(4): 478–484, 2008.
ISSN: 1809-127X

NOTES ON GEOGRAPHIC DISTRIBUTION

Figure 1. Distribution map of *Rhinella atacamensis* showing the 25 localities known to date. The boundaries of the administrative regions and the principal rivers located between 25° and 32° S are also shown. The Choapa River and Pupío stream basins constitute the southern known limit for this species.

Check List **4**(4): 478–484, 2008.
ISSN: 1809-127X

NOTES ON GEOGRAPHIC DISTRIBUTION

Cei (1961, 1962) suggested that the subspecies *B. s. atacamensis* is replaced by the subspecies *B. s. arunco* (now *R. arunco*) from the city of Coquimbo south (30° S). With regard to altitudinal limits, Cei (1962) pointed out that the altitude reached by *B. s. atacamensis* in the Andes was unknown along the Copiapó and Huasco rivers. Veloso and Navarro (1988) defined the altitudinal range for *B. atacamensis* as being between sea level and 2000 m.

Forty years after the Cei (1962) publication, various studies have allowed the redefinition of the southern limit of the distribution of *R. atacamensis*. Sallaberry and Méndez (2002) reported new localities which extended this limit to Socos (30°44' S). Furthermore, Moreno et al. (2002) reported the presence of the species in the Llanos de Challe National Park (28°10' S). Subsequently, Sallaberry et al. (2007) added new localities within the range defined by Sallaberry and Méndez (2002) and also extended the distribution by more than 150 km southward, to Mauro (31°57' S) (Figure 1). The implications of these changes in the southern distributional limit of *R. atacamensis* is that the distribution of this species and that of *R. arunco* should overlap between 30° and 31°57' S, if we accept the limits established by Cei (1961, 1962) for both species.

Nevertheless, intense explorations between Paposo and Mauro carried out between 2005 and 2007 were only able to find populations of *R. atacamensis* in this area, whose specific status can be established without ambiguity based on external morphological characteristics of individuals. Also, the 2007 expeditions revealed new localities of occurrence of *R. atacamensis*.

Table 1. Coordinates and altitudes for *Rhinella atacamensis* localities reported in the literature (where it appears as *Bufo atacamensis*), and others recently discovered (this report), ordered by latitude from north to south. See map in Figure 1.

Locality	Latitude (S)	Longitude (W)	Altitude (m)	Reference
Paposo	25° 01' 33.2"	70° 27' 10.3"	332	Cei (1962)
Las Bandurrias	25° 12' 01.0"	70° 26' 01.0"	30	Sallaberry and Méndez (2002)
Las Breas	25° 30' 00.3"	70° 24' 01.7"	611	This report
Las Chilcas	26° 03' 48.8"	70° 32' 18.3"	407	Sallaberry and Méndez (2002)
Finca de Chañaral	26° 38' 57.9"	69° 51' 38.4"	1504	Sallaberry and Méndez (2002)
Mostazal	26° 40' 53.9"	69° 34' 14.8"	2574	This report
Carrera Pinto	27° 06' 40.2"	69° 53' 44.3"	1565	This report
Aguada de Chorrillos	27° 12' 49.8"	70° 56' 52.0"	27	Cei (1962)
Copiapó	27° 21' 55.7"	70° 20' 32.7"	381	Cei (1962)
Quebrada La Higuera	28° 01' 21.3"	70° 16' 29.5"	1100	Sallaberry et al. (2007)
Quebrada Los Sapos	28° 04' 48.4"	70° 24' 35.2"	1002	Sallaberry et al. (2007)
Las Cañas	28° 10' 12.1"	71° 06' 11.5"	323	Moreno et al. (2002)
El Pino	28° 29' 03.6"	71° 08' 45.0"	25	This report
Relincho	28° 32' 16.5"	70° 16' 03.3"	1546	This report
Vallenar	28° 35' 07.7"	70° 44' 38.9"	403	Cei (1962)
Pajonales	29° 08' 42.9"	70° 59' 45.2"	1010	Sallaberry and Méndez (2002)
Cruce a Chungungo	29° 35' 12.5"	71° 15' 10.4"	161	Sallaberry et al. (2007)
Quebrada de Talca	30° 03' 49.2"	71° 04' 21.7"	515	This report
Las Barrancas	30° 12' 43.4"	71° 16' 25.9"	209	This report
Socos	30° 43' 52.4"	71° 29' 27.8"	96	Sallaberry and Méndez (2002)
Talinay	30° 48' 39.5"	71° 36' 46.4"	250	This report
Canela Alta	31° 23' 08.2"	71° 25' 11.7"	307	Sallaberry et al. (2007)
Los Perales	31° 28' 46.3"	71° 07' 24.6"	653	This report
Mauro	31° 56' 59.5"	71° 03' 50.7"	764	Sallaberry et al. (2007)
Río del Totoral	31° 59' 04.0"	70° 30' 58.8"	1581	This report

Check List **4**(4): 478–484, 2008.
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NOTES ON GEOGRAPHIC DISTRIBUTION

The main objective of the present study was to define more precisely the distributional range of *R. atacamensis* by reviewing all its recorded localities cited in the literature, as well as adding the new discoveries from 2007. We also present photographic material to demonstrate how human activities have altered the habitat of the species, particularly in the northern region of its distribution. We found a total of 15 localities in the literature (Cei 1961; 1962; Moreno et al. 2002; Sallaberry and Méndez 2002; Sallaberry et al. 2007), to which we have added the 10 new ones discovered in 2007, which are located within the latitudinal limits defined in those references (Table 1; Figures 1 and 2). Both adults and juveniles were identified from their external morphological characters.

Among the new localities, three are included in which the species was recorded from individuals which were photographed (El Pino, Las Barrancas and Río del Totoral). The altitudes of the 25 localities ranged between 20 m (Las Bandurrias) and 2574 m (Mostazal). The latter locality, a ravine within the Atacama Desert, represents the highest record for the species to date. As a group, the 25 known localities are distributed more or less equidistantly along both the coast and the interior of the country, over a range of approximately 750 km (25°-32° S; Figure 1). From a hydrogeographic perspective, these localities occur both in Andean (representing those with the largest extensions) and pre-Andean basins, and in basins of the coastal range.

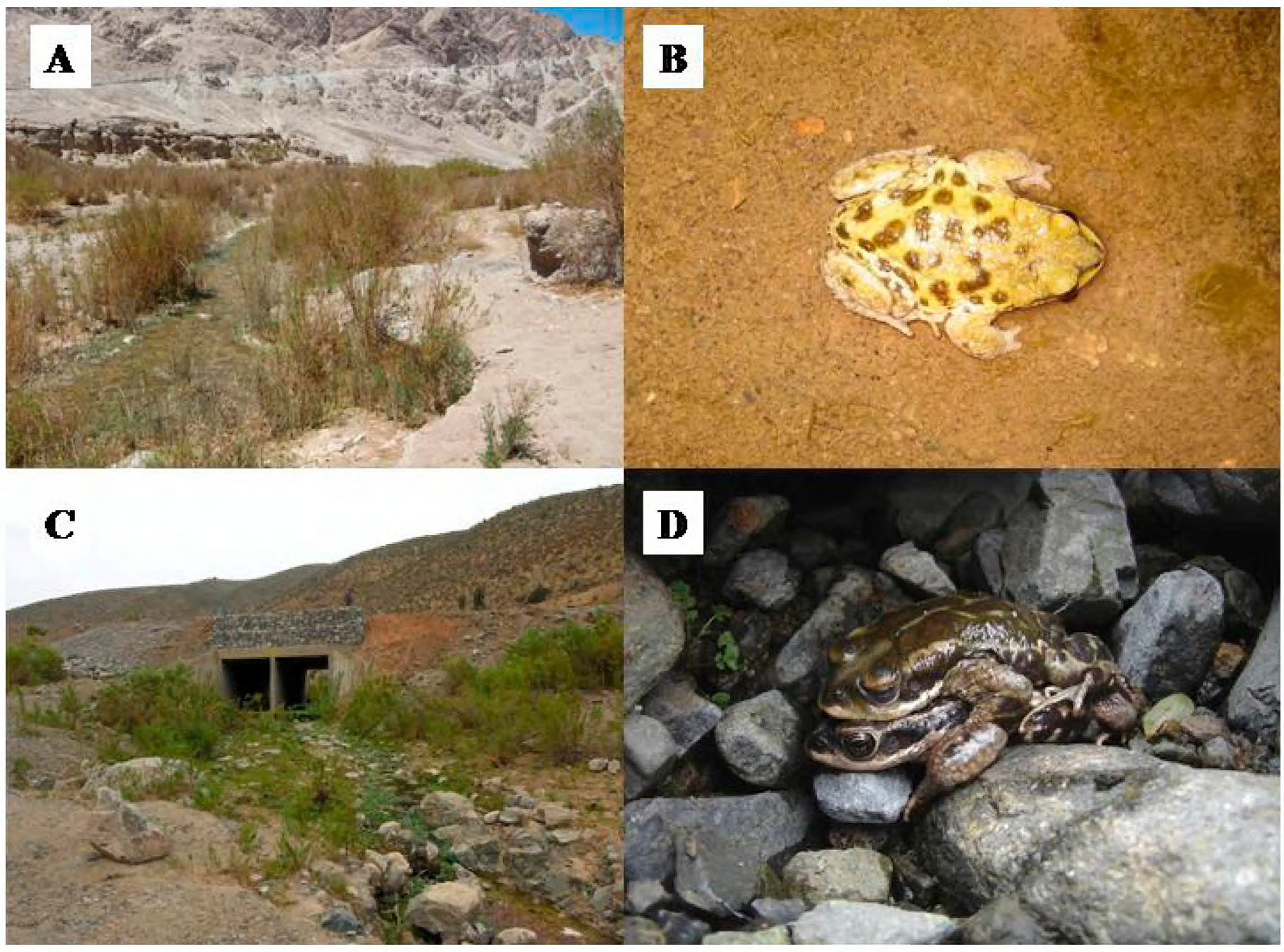

Figure 2. New localities and specimens of *Rhinella atacamensis* photographed in the field. A and B: Carrera Pinto Oasis, Atacama Region. This locality is threatened by massive extraction of water for agricultural and mining activities developed along the watercourse. On the right, a partially submerged male individual photographed at night. C and D: Los Perales locality, Coquimbo Region. Although occurring along a highway, this site appears unaltered by human activities. On the right, a pair of specimens in amplexus photographed in July 2007. *R. atacamensis* shares the habitat with *Pleurodema thaul* in both localities.

Check List **4**(4): 478–484, 2008.
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NOTES ON GEOGRAPHIC DISTRIBUTION

The finding of new localities for *R. atacamensis* and the absence of any indication of the presence of *R. arunco* between 30° and 32° S, reported in publications since 2002, indicates that there is no overlap of these two species as suggested from an analysis of all the literature available to date. Thus, *R. arunco* effectively replaces *R. atacamensis* from the Pupío stream basin southward. These limits are confirmed by a phylogeographic study of mitochondrial DNA which includes populations of both species located between 25° and 36°15' S (Correa et al., unpublished data). With regard to *R. spinulosa*, it also appears there is no overlap, since this species has not been collected between 23°47' S (Tilomonte) and 32°51' S (Portillo). The finding of populations of *R. atacamensis* above 1500 m suggests that it is the only amphibian species which inhabits the piedmont and mountains between 23°47' and 31°45' S. It is also possibly the only species that inhabits the coast and interior of Chile between 25° S and Carrera Pinto (27°07' S), which is the northern distributional limit of *P. thaul* (Correa et al. 2007).

The continuing discovery of new locations of occurrence of *R. atacamensis* has decreased the gaps previously observed in its distribution, what suggests that the species is more common than previously supposed and may be present in a large number of freshwater bodies between Paposo and Mauro (25-32° S) (Figures 1 and 2). Nevertheless, in parallel with the increase in the number of localities cited for the species, environmental deterioration has been noticed at some of these, particularly in the northern part of its distributional range. For example, two of the localities mentioned by Cei (1961, 1962), Copiapó and Vallenar, have been strongly affected by the modification of the courses of the Copiapó and Huasco rivers, respectively. The Copiapo River is becoming dry over a large part of its middle and lower portions due to removal of water for intense agricultural use (Hajek et al. 1990; Figure 3B). Among the localities recently described, Finca de Chañaral has become totally desiccated due to removal of water (Figure 3A), while Mauro, representing the southern limit of the distribution, has been practically destroyed by mining activity. Other localities have been drastically modified by road work, such as the El Peral grade in Paposo and Quebrada Los Sapos, where road construction has had serious effects on the reproductive sites of the species (Figure 3). At present there are only two localities within protected areas; Las Chilcas, in the Pan de Azúcar National Park and Las Cañas, in the Llanos de Challe National Park (Table 1), which represent only a small proportion of the area occupied by the species. All the other remaining localities occur near human settlements where mining, farming, ranching, and/or tourist activities develop, exerting a strong pressure on local water resources.

Based on recent evaluations of the conservation state of amphibians in Chile, *R. atacamensis* is classified as "out of danger", or of least concern (Díaz-Páez and Ortiz 2003; Veloso 2006). Likewise, it is considered as a species of least concern by the International Union for the Conservation of Nature (Veloso and Nuñez 2004). These classifications differ from previous evaluations which had considered it as a vulnerable species (Glade 1988; Formas 1995; Núñez et al. 1997). It should be noted that most of these evaluations were based fundamentally on judgments made by experts (qualitative information), following the guidelines of the IUCN (Thornback and Jenkins 1982). Only recently have quantitative data been taken into account to define the threatened species categories, including population sizes, geographic distribution, and analyses of the probability of extinction (IUCN 2001). Some of the preceding data have been incorporated into recent evaluations of the state of conservation of Chilean amphibians (Díaz-Páez and Ortiz 2003). Nevertheless, it is difficult to establish a correct categorization for *R. atacamensis*, since population studies have not yet been carried out on the species, and thus it is only possible to speculate on some aspects such as size and connection of its populations. Also, as the present report shows, information on its real distribution in Chile is still being developed. Within this context, and in the absence of quantitative information, the lack of protection over most of its range, accelerated destruction and modification of its habitats and threats due to human management of water resources over its entire distribution need to be considered in order to reevaluate the status of conservation of *R. atacamensis*.

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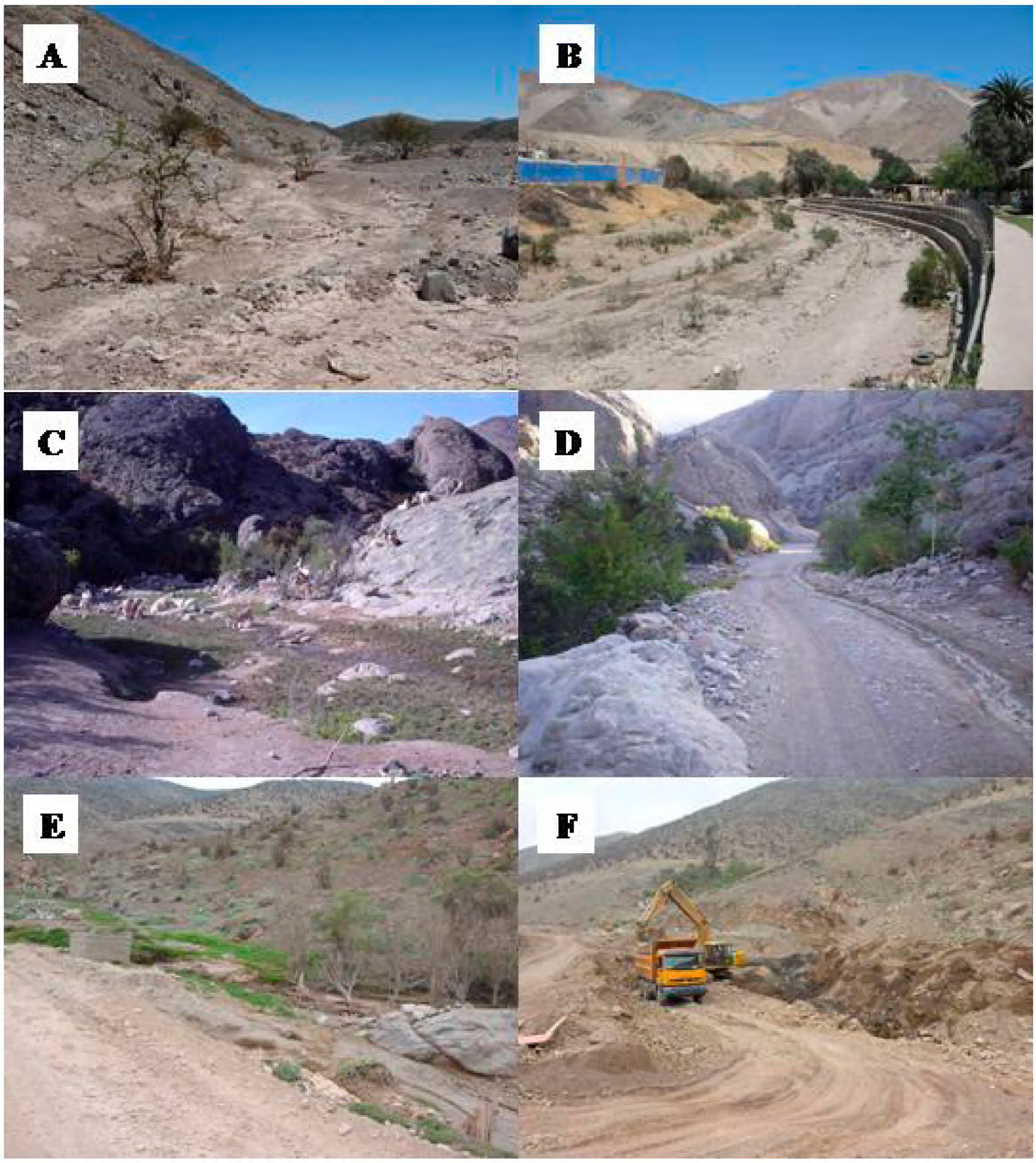

Figure 3. Current state of some localities of *Rhinella atacamensis* located in the regions of Antofagasta and Atacama. A. Finca de Chañaral, Atacama Region, October 2007. This site, fully within the Atacama Desert, was the northernmost locality described in the interior of Chile. It is at present completely dry due to intensive human use of the water. B. City of Copiapó, Atacama Region, October 2007. The bed of the Copiapó River close to the city is at present completely dry. *R. atacamensis* used to inhabit this site of the river 30 years ago. C: Quebrada Los Sapos, Atacama Region, November 2005. D: The same location in February 2008. A road built in the middle of the ravine restricted the water to a few pools which form on its edges. E: Paposo, Antofagasta Region, November 2005. F: The same location in January 2007. This locality was recognized by Cei (1962) as the northern distribution limit, and held an abundant population. This site is now affected by road construction which almost completely destroyed the reproductive sites of the population. The species was sympatric with *Pleurodema thaul* only in the Copiapó locality.

Check List **4**(4): 478–484, 2008.
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NOTES ON GEOGRAPHIC DISTRIBUTION

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